

MAX6954 Display Driver

A driver for 14/16 segment displays

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LED displays offer a number of advantages over other display technologies: they are reliable, robust, easily readable from a wide viewing angle and are relatively simple to drive. Along with the more usual 7-segment and dot matrix types come the 14/16 segment displays. This article takes a closer look at a versatile driver IC from Maxim.

14/16-Segment displays are arranged like 7-segment types but with additional diagonals and centre vertical segments. These extra segments allow many more characters (including special characters) to be displayed but the extra segments demand a more complex driver circuit. There is any number of 7-segment drivers on the market but for 14/16 displays the choice is relatively small. The

MAX 6954 and MAX 6955 from Maxim are designed to meet this need and can also drive 7-segment displays and discrete LED indicators.

SPI or I²C?

The function of both the MAX6954 and MAX6955 are similar. The only difference between the two devices is the interface standard used to connect the device to the

microcontroller. The MAX6954 uses an SPI (serial programming interface) while the MAX6955 uses an I²C interface. Both ICs are highly integrated and this short article only touches on some of the features of the chip, for a more detailed description it is necessary to refer to the (38 page) data sheet [1].

Figure 1 shows the internal block diagram of the MAX6954 and the complete circuit diagram for this application. The supply voltage should lie between 2.7 V and 5.5 V (it can withstand 6 V for a short period only). The supply current consumption is 35 mA maximum and typically 22 mA. Current to the segments is limited by an internal programmable constant current source. The character driver can be programmed so that the intensity of the entire eight display characters is defined together (globally) or the intensity of each character is individually programmed. The intensity is defined by the value of the lower four bits written to the intensity register. This allows

16 steps in the display brightness so with a segment drive source current of typically 40 mA, each step represents a 2.5 mA reduction in the drive current.

The internal clock frequency is controlled by an external capacitor (typically 22 pF) connected between the OSCIN input pin and ground. All the internal processes in the LED controller including the LED blink frequency are referenced to this oscillator clock. The clock output from OSCOUT (pin 37) can be used to synchronise external circuitry to this driver clock.

The LED drive circuitry has 19 outputs O0 to O18 and employs a number of different multiplexing techniques to reduce wiring complexity. Firstly the drive is time multiplexed so that at one point in the cycle the lower eight outputs are used to sink current from the common cathode connection of the LED while at other times the current direction is reversed and the output acts as a current source to drive an individual

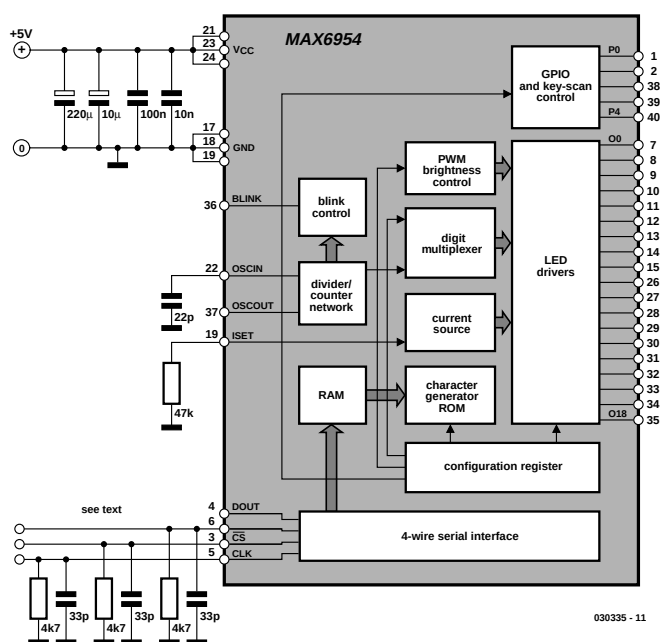


Figure 1. Circuit diagram showing internal block diagram of the 40-pin DIL version.

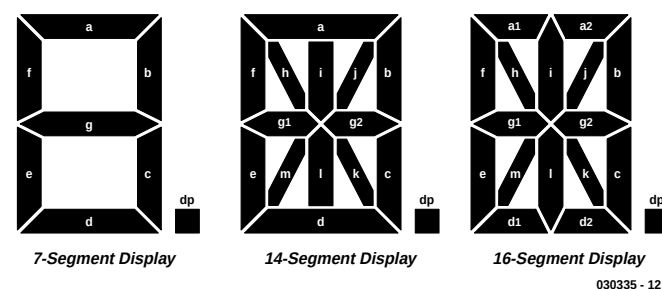


Figure 2. 7, 14 and 16 Segment LED displays.

segment on the display. The display brightness is controlled by using pulse width modulation. A built in current source generator limits the maximum LED current and a single resistor connected between pin 19 and ground defines the value of this current. The manufacturer suggests a resistor value of 56 kΩ.

Each display position has two registers associated with it (called plane 0 and plane 1). One of these registers contains the actual display information whilst the other register is a 'background' register. This allows new information to be loaded to the background register and then quickly swapped with the display register using just a single command. An internal decoder and character generator allows 104 characters from the ASCII character set (including some special characters) to be displayed. The chip also contains a decoder for use with seven-segment LEDs.

Some of the outputs can also be used to scan up to

32 input switches or a keyboard. The chip also performs built-in switch debouncing. A part of this keyboard interface can also be used as a general-purpose I/O port.

The internal Registers

The display driver has a complicated internal structure including a large number of internal configuration registers to control the chip and all its functions. The values that need to be written to these registers and their interdependence on the contents of other registers make the programming process a little complicated.

Some of the important registers used in our application are described below but for a fuller appreciation of the capabilities of this chip it is necessary to spend a little time studying the data sheet.

No-op (00H)

This allows data to be sent to just one driver chip when, say, four are daisy chained together. The No-op com-

mand is sent to the other three devices.

Decode-Mode (01H)

This register determines whether the ASCII decoder will be used to generate the displayed character or the LED segments will be individually driven. The type of LED used (defined in register 0CH) will influence the decoded output.

Global Intensity (02H)

If the global bit is set in 0C register the entire display can be dimmed (15 levels).

Scan Limit (03H)

Sets the number of segments used for the display LEDs. Also used to limit the number of keys scanned if input keys are used.

Configuration (04H)

This register controls the configuration of the chip. For normal operation Bit 0 must be set to a '1' otherwise the chip enters its shutdown mode. Bit 1 is unused. Bit 2 controls the blink rate. If the bit is set the blink rate will be approxi-

mately 2 Hz otherwise it will around 1 Hz (assuming a 4 MHz clock). Bit 3 inhibits (0) or enables (1) display blinking. The blinking can be used to flash the display on and off or alternately to display two different characters. Bit 4 resets the blink timer. This is useful in a system with multiple display drivers: resetting this bit on all the drivers in quick succession will ensure that blinking of all the displays will be synchronised. Bit 5 clears all the display data stored in both display planes. Bit 6 is used to define the type of display intensity control. A '0' in this position means that the intensity of the whole display will be set by the value stored in register 02. A '1' allows each displayed character to have an intensity defined by the 4-bit values stored in registers at address 10H to 17H. Bit 7 is read only and indicates whether the display is currently on or off in the blink cycle.

GPIO Data (05H)

This register is used to output

Connection(s)	Function		
1, 2, 38, 39, 40	Freely programmable I/O-Ports, configurable as inputs or as open-drain outputs. Also used by keyboard interface.	17, 18, 20 19	Ground connections. Connected to resistor that determines the maximum output current of the drivers.
3	CS connection of SPI.	21, 23, 24	Positive supply voltage connections. Good decoupling required because the LED drivers are capable of very fast switching.
4	Allows multiple MAX6954's to be daisy-chained. Also acts as a data output if internal register values are to be read back.	22	Connect to a capacitor to determine speed (frequency) of all internal operations. Also accepts external clock.
5	Clock input for SPI.	36	Supplies blink rate for external synchronisation purposes. Open-drain output.
6	Data input for SPI. Copy receive register numbers and values to this pin.	37	Supplies buffered Internal oscillator clock signal to synchronise other MAX6954s.
7-15, 26-35	Outputs for LED display. These pins work in digit as well as segment drivers. Non-activated drivers go into hi-impedance state.	16, 25	Not connected.

data on the General Purpose I/O pins. Input data can be read from address 85H.

Port Configuration (06H)

Selects how the five port pins outputs are used in the circuit.

Display Test (07H)

A 1 in this register will light all the LED segments including the decimal point. Normal operation continues when the register is 0.

Key Mask/Key Debounce (08H to 0BH)

These four registers are used if a keypad is connected, it allows some selected (masked) keys to generate an interrupt when the key press has been debounced.

Digit Type/Key Pressed (0CH)

The type of display can be written to this register. The register is divided into 4 'slots' of 2 bits, these are used to define the display type. Maxim have an example configuration program available to download from their website.

Intensity (10H to 17H)

This changes the brightness of each individual character or of all characters together

depending on the global bit setting in the configuration register (0CH).

Digit Plane 0 (20H to 2FH)

These 16 registers store the displayed characters. The interpretation of these characters is dependant on the number of segments used for the display LED used (digit type in register 0CH). For 14 or 16 segment displays the seven LSBs indicate the ASCII value of the display character. The MSB controls the decimal point. In 7-segment mode with decoding bits D0 to D3 are decoded via the ASCII look up table while D7 controls the decimal point. If the decode mode is not selected each bit will directly control an LED. These registers act as the 'foreground' stores and are displayed during the first blink phase (plane P0).

Digit Plane 1 (40H to 4FH)

Identical to Digit Plane 0 but the contents are displayed in the second blink phase (background register).

Digit Plane 0/1 (60H to 6FH)

Data written to these address ranges will write to both P0 (20H to 2FH) and P1 (40H to 4FH) at the same time. These

are not new registers but a command to write to both the P0 and P1 register stores together.

Key Debounced/Pressed (88H to 8FH)

A '1' in any position in this register indicates that a key press was detected in this position during the last key scan routine. It can determine if the key was pressed momentarily or if the key was held down.

The internal ASCII character generator does not contain any lower-case characters (they cannot be represented on the displays) and will always output upper-case characters irrespective of whether the upper case or lower case ASCII code is used. The special characters are displayed using codes in the range of 08H to 2FH.

A simple application

The circuit diagram of a simple application example (Figure 1) shows how few external components are necessary to implement a display. The most difficult part of circuit construction is the wiring between the driver circuit

and the LEDs. Connections to the LEDs are not detailed on the circuit diagram because pin-outs are generally not consistent between different types of LED from different manufacturers. The data sheet from Maxim details these interconnections (O0 to O18) to various display devices including a discrete LED matrix and 7 to 16 segment displays.

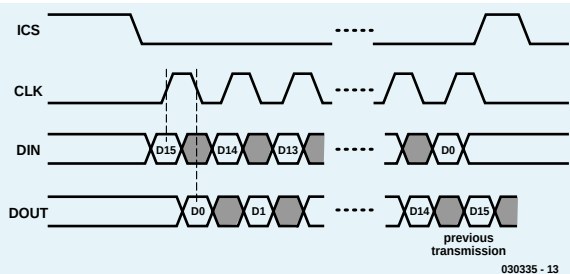
The SPI to the driver chip uses a minimum of three signal wires (together with earth of course). An extra wire can be fitted (DOUT pin 4) if it is necessary to read back information from the chip registers. Included with the development board from Maxim is a complete software package for program development, the author chose QBASIC. This software allows simple access to the PC parallel printer port running in DOS. The source files are all available free to download from the Elektor Electronics website, look for file number **030335-11** under month of publication.

The first program employs some of the basic features of the MAX6954. Eight values are input and displayed on the LEDs. The

SPI data transfer

The input signal thresholds of the SPI-Interface are fixed at 0.6 V and 1.8 V, this enables the device to be interfaced directly to both 3 V-CMOS and 5 V-TTL logic families. The input current to the interface is approximately 1 mA. Signal reflections on the SPI interface can sometimes be a problem (particularly at 5 V) so it is recommended to terminate the DIN, $\overline{CS}$ and CLK signals with either a 4.7 K Ω or a 33 pF capacitor to ground. To transfer data a the $\overline{CS}$ input is pulled low to indicate the start of data transmission, the most

significant bit of the data stream is now presented to the DIN pin and this bit is clocked into an internal shift register on the rising edge of the clock. This process repeats until the last bit of the data stream is received, $\overline{CS}$ now goes high before the clock signal goes low and this will store the received message into an internal latch. Each message is 16 bits long, the most significant eight bits defines both the 7-bit address of the internal register and the read/write bit while the next eight bits are the data to be written into that register. The chip can be clocked at 8 MHz but MAXIM recommend a more conservative 4 MHz.



program consists of an initialisation routine, display data input and a central data transfer routine. The

second program implements a running-text display with a maximum message length of 80 characters. The initial-

isation procedure is identical to the first program. Both of the programs are a little basic (ouch) but should help

to clarify the steps necessary to configure the internal registers.

(030335-1)

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